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ABSTRACT

The purpose of this study was to provide students with differing types of learning needs instruction following diagnostic testing; also examined were the effects of the instruction on science achievement and retention. A total of 154 seventh-grade students from six classes completed a five-week block of instruction in earth science composed of units on earth motion, latitude and longitude, and map skills. Teachers were provided with performance objectives, diagnostic progress tests, unit tests, learning materials, and activities. Students were stratified on three levels of aptitude and randomly assigned to one of three treatment conditions: (1) control; (2) teacher-directed remedial work; and (3) student-directed remedial work. Achievement and retention data were analyzed using a 3 X 3 (aptitude X treatment) analysis of variance with quantitative scores from the Iowa Test of Basic Skills as covariates. Both groups of students receiving diagnostic tests scored significantly higher than the control group. Significant differences were found between the two groups of students that received teacher- or self-guided remediation on only one unit. Analysis of the retention test data showed that initial differences measured were not apparent after a two-month span. (MH)

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# THE EFFECTS OF DIAGNOSTIC TESTING AND REMEDIATION ON SCIENCE ACHIEVEMENT AND RETENTION

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# THE EFFECTS OF DIAGNOSTIC TESTING AND REMEDIATION ON SCIENCE ACHIEVEMENT AND RETENTION*

A number of studies conducted during the last few years have shown that diagnostic-progress tests followed by remedial instruction can be used to increase the achievement of pupils (Block and Burns, 1976). A diagnostic or formative test is a brief progress test keyed to specific performance objectives. Diagnostic testing provides vital feedback to teachers as well as pupils. From the results of diagnostic testing, teachers are able to monitor pupil progress, identify instructional weaknesses, and modify instruction accordingly. Pupils are able to identify gaps in their learning without the penalty of final judgment (in the form of grades) and to take necessary corrective measures.

Following diagnostic testing and tabulation of results, some effective remediation strategy is needed for pupils who have not obtained minimum achievement levels. The methods of providing remediation following diagnostic testing can be grouped into two major categories; teacher-directed remedial and pupil-directed remedial work. Teacher-directed remediation is defined as any remedial instruction structered, organized, and prescribed by the teacher. Pupil-directed remedial work is defined as any course of corrective action conceived and undertaken by pupils based on diagnostic test results.

Several studies have shown that as the amount of assistance with diagnosis and remediation increases, achievement scores show a corresponding increase. Collins (1971) studied mathematics learning with six groups of elementary pupils. The increments of assistance in this study ranged in

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variation from no assistance for the control group to performance objectives, diagnostic problems, knowledge of results, and provision of alternate remedial resources for the group receiving maximum assistance. Collins found that while only 40% of the control group scored at the A or B level on the summative achievement test, 80% of the group receiving maximum assistance reached these same levels of achievement.

In a study consisting of five groups of undergraduate college students receiving physical science instruction, Goodson and Okey (1976) found significant treatment effects among groups receiving different increments of diagnostic assistance and variation in types of remediation. The types of remediation included a) reteaching incorrect responses on the diagnostic test, b) encouraging students to ask questions concerning items missed on the diagnostic test, and c) instructing students to find, on their own, answers to incorrect responses on the diagnostic test. The groups receiving some form of teacher-directed remediation scored significantly higher on short-term achievement measures than groups receiving no assistance or groups planning their own remediation.

In the extensive summary of research on diagnostic-remedial procedures prepared by Block and Burns (1976), it was concluded that pupils receiving maximum learning guidance retained knowledge longer than groups receiving less assistance. In the retention studies that they review (about 30 in number) involving instructional intervals ranging from a few weeks to a few months, pupils receiving learning assistance scored significantly higher 63% of the time and generally higher almost all of the time. The cause and effect relationships between specific components of assistance (i.e., performance objectives, diagnostic testing, prescriptive remediation) and retention have not, however, been firmly established. This is illustrated in the Goodson

and Okey (1976) study cited earlier in this paper. While the groups receiving a form of teacher-directed remedial work scored higher on initial achievement measures, retention results favored the groups planning their own remediation.

The intent in this study was to provide learners with differing increments and types of remedial assistance and examine the effects on short-term cognitive achievement, retention, and attitudes toward instruction. Affective outcomes were of concern in this study because the amount of interaction between students and teachers varies depending on the amount of participation by teachers in directing remedial work that follows diagnostic testing. Studies involving the affective consequences of diagnostic-prescriptive teaching have not been as extensive as the cognitive studies. While these studies have often favored groups receiving diagnosis and prescription, the findings are inconclusive (Block and Burns, 1976).

Research Questions

1. Will science achievement and retention be influenced by the types and amount of diagnostic-remedial assistance that students receive?
2. Does diagnostic-prescriptive assistance have a consistent influence on student achievement across units in a science course?
3. Will student attitudes and opinions about their science instruction be influenced by the type and amount of diagnostic-prescriptive assistance that they receive?

The rationale for selection of the independent variables in this study (i.e., the amount and type of assistance in diagnostic-prescriptive instruction) arises from an awareness of the day-to-day problems encountered by teachers. Fixed time schedules, heavy course loads, and large classes combine to discourage many teachers from any attempts to provide instruction that identifies and treats individual learning problems. Considering the time and materials

required to include diagnostic evaluation and remedial work as part of instruction, it is not unreasonable for teachers to await assurance that their efforts are likely to bring about favorable cognitive and affective outcomes.

## Methodology*

### Sample

All the eighth grade students (n=159) from a middle school served as the subjects for the study. The students came from classes taught by 3 teachers who taught science in adjoining rooms during the same period at two times (morning and afternoon) each day. The students were primarily from middle to low socio-economic status homes. The racial composition of the group was approximately 35 percent black and 65 percent white.

### Design

A 3 x 3 (aptitude x treatment) design was used in the study. This was done by using scores from a teacher-made aptitude test to establish groups of high (top third), middle, and low (bottom third) aptitude students. Students from each aptitude group were then assigned at random to three experimental groups. Each of the three teachers was randomly assigned to one of the groups of students and experimental treatments were randomly assigned to each of the teachers.

The process of assigning students, teachers, and treatments was done for the morning block of classes and repeated for the afternoon block. The result was to achieve a random assignment of students to treatments and a

*The assistance of Dr. Frusanna Booth, Dr. Helen Westbrook, Ellen Hanna, Mabel Mitchell, and Ron Patenaude (all from the Clarke County Public Schools) in arranging for and conducting this study is greatly appreciated.

random assignment of treatments to teachers. Morning and afternoon students in the same treatment group were considered one block of students in the data analysis.

Teachers rotated assignments with students and treatments for the three units so that each teacher taught each group of students and used each treatment condition. This was done to remove the systematic bias that might result from a teacher consistently using one method of instruction or working with one group of students. The practice of rotating students to different teachers for different units was already followed in the school so students were accustomed to this procedure before the experiment began.

## Treatments

The teachers administered the treatments using materials especially developed for this study. The materials prepared for the 5-week block of instruction (covering units on earth motion, latitude and longitude, and map skills) included:

- 28 performance objectives for the three units
- 9 reading assignments (from 2 textbooks) keyed to the objectives
- 12 worksheets for students to complete individually or in pairs
- 9 group demonstrations for the teacher to give (requiring about 15 minutes each) during the three units (e.g., using a globe and flashlight in a darkened room to show how the number of daylight hours varies with the season).
- checklists to guide students through the readings, worksheets, and demonstrations.
- 56 diagnostic test items keyed to the objectives (two per objective). These were provided as two versions each of 13 diagnostic progress tests, each consisting of 2 or 3 items on 1 or 2 objectives.

The materials just described were used by the teachers under three treatment conditions.

Treatment 1 (Control Group)

Students received the same instructional materials as the other two groups except that no objectives were given to them, no diagnostic progress tests were administered, and no remedial instruction undertaken.

Treatment 2 (Student-Directed Remedial Work)

Students were provided with objectives, reading assignments, worksheets, group demonstrations, and checklists. Diagnostic progress tests were given on an individual basis at about 2-day intervals when the corresponding learning materials had been completed. Diagnostic tests were scored immediately or over night. The tests were returned to the students and they were told to use the results to guide their own efforts to correct errors. No follow-up progress tests were given and teachers did not make additional attempts to identify or remedy learning problems.

Treatment 3 (Teacher-Directed Remedial Work)

Students followed instruction the same as in Treatment 2 except that they were given specific assignments of remedial work to complete to correct any problems shown by the tests. A second progress test was given following this additional study. If problems persisted, the teacher attempted to use individual tutoring to solve them. Students that were still having difficulty at this point were encouraged to move on to new material even though they had not achieved the objectives.

## Instruments

Tests referenced to the objectives provided to the teachers were given at the end of each of the three units (about every 8 instructional days). An unannounced retention test covering all three units was given 12 weeks after completion of the final unit. The collective judgment of the experimenters was used to establish that the items on all measures provided valid tests of the stated objectives. Students also completed a questionnaire after the study to determine their attitudes toward the instruction. Table 1 provides a summary of the instruments used in the study.

All tests were scored in random order by the investigators so that it was not known to which treatment group a paper belonged. Model answers were prepared and papers were scored on the degree to which answers provided by students fit the model answers.

TABLE 1

INFORMATION ON THE INSTRUMENTS USED IN THE STUDY

| Instrument | Purpose | Number and Type of Items | Time to Complete (minutes) | Reliability Estimate* |
|---|---|---|---|---|
| Student Questionnaire | Measure attitudes toward instruction. | 10 items, Likert scale | 10 | .76 |
| Earth Motion Test | Unit test on objectives | 28 items, open response | 30 | .92 |
| Latitude and Longitude Test | Unit test on objectives | 26 items, open response | 30 | .94 |
| Map skills Test | Unit test on objectives | 31 items, open response | 40 | ** |
| Retention Test | Measure long-term retention | 36 items, multiple choice | 25 | .93 |

*Reliabilities were determined by selecting 30 papers at random from all papers available and calculating the split-half reliability. The resulting reliabilities were then stepped up to the original test length to produce the value reported here.

**This unit test was corrected, recorded, and then lost before reliability estimates could be made.

## RESULTS

The group achievement means for the 3 science units, the retention test mean scores, and the mean attitude scores are presented in Table 2. Two-way analysis of variance procedures with treatment and aptitude as main effects variables were employed to determine the probability of real differences among these means.

TABLE 2

MEANS AND STANDARD DEVIATIONS OF ACHIEVEMENT AND ATTITUDE SCORES ACROSS TREATMENTS

| | $T_1$ | $T_2$ | $T_3$ | S.D. |
|---|---|---|---|---|
| Unit 1* | 29.4 | 31.2 | 36.5 | 9.1 |
| Unit 2* | 27.0 | 34.8 | 34.7 | 10.6 |
| Unit 3* | 36.8 | 35.7 | 39.2 | 9.8 |
| Retention** | 21.8 | 21.6 | 22.3 | 4.6 |
| Attitude*** | 36.5 | 37.7 | 34.8 | 6.5 |

*maximum possible score = 60
**maximum possible score = 36
***maximum possible score = 50

On the basis of the calculated F ratios, the main effects of treatment and aptitude both appeared to have influenced achievement in Unit 1 (See Table 3). Further analyses were needed to determine which treatment groups were achieving significantly better than others. Newman-Keuls post-hoc comparison procedures were chosen for this purpose and indicated that the $T_3$ (teacher-directed remediation) group achieved significantly better than any other group ($p<.05$). No other differences due to treatment were found.

TABLE 3

ANALYSIS OF VARIANCE SUMMARY
TABLE FOR ACHIEVEMENT ON UNIT 1

| Source of Variation | df | Mean Square | F | p |
|---|---|---|---|---|
| treatment | 2 | 370.0 | 4.46 | .013 |
| aptitude | 2 | 8590.6 | 103.63 | .001 |
| T x A | 4 | 151.9 | 1.83 | .125 |
| error | 131 | 82.9 | | |

The calculated F values on the main effects again indicated that there was a significant difference due to treatment and aptitude in Unit 2 (see Table 4). Post-hoc analyses indicated that significant differences in achievement favored $T_3$ (teacher-remediation) and $T_2$ (self-remediation) over $T_1$ (control). No other differences due to treatment were found.

TABLE 4

ANALYSIS OF VARIANCE SUMMARY TABLE FOR
ACHIEVEMENT ON UNIT 2

| Source of Variation | df | Mean Square | F | p |
|---|---|---|---|---|
| treatment | 2 | 956.1 | 8.47 | .001 |
| aptitude | 2 | 8396.7 | 74.35 | .001 |
| T x A | 4 | 145.4 | 1.29 | .227 |
| error | 131 | 112.9 | | |

Two-way analysis of variance procedures were also used to assess difference in achievement which could be attributed to the effects of treatment in Unit 3 and on the retention test. The analyses revealed no significant differences ($p<.05$) which could be attributed to treatment (see Tables 5 and 6).

TABLE 5

ANALYSIS OF VARIANCE SUMMARY TABLE FOR ACHIEVEMENT ON UNIT 3

| Source of Variation | df | Mean Square | F | p |
|---|---|---|---|---|
| treatment | 2 | 45.3 | .46 | .999 |
| aptitude | 2 | 7349.3 | 77.12 | .001 |
| T x A | 4 | 47.2 | .50 | .999 |
| error | 131 | 95.3 | | |

TABLE 6

ANALYSIS OF VARIANCE SUMMARY TABLE FOR RETENTION ON ALL UNITS

| Source of Variation | df | Mean Square | F | p |
|---|---|---|---|---|
| treatment | 2 | .02 | .001 | .999 |
| aptitude | 2 | 1455.67 | 67.58 | .001 |
| T x A | 4 | 32.98 | 1.53 | .196 |
| error | 131 | 21.54 | | |

On all the data analyses, student aptitude was entered as a three-level factor in the design. In all cases the aptitude variable appeared as a significant ($p<.001$) main effect (see Tables 3, 4, 5 and 6). Post-hoc analyses indicated that without exception the high aptitude group achieved significantly above the middle group which achieved above the low.

The analysis for treatment effects on the attitude mean scores indicated no significant differences among treatments (see Table 7). However, all groups expressed a positive attitude toward the instruction.

TABLE 7

ANALYSIS OF VARIANCE SUMMARY TABLE FOR ATTITUDE TOWARD METHOD OF INSTRUCTION

| Source of Variation | df | Mean Square | F | p |
|---|---|---|---|---|
| treatment | 2 | 97.1 | 2.3 | .105 |
| aptitude | 2 | 109.8 | 2.6 | .08 |
| T x A | 4 | 21.2 | .5 | .999 |
| error | 133 | 42.8 | | |

## Discussion and Conclusions

The results of this study indicate that science achievement is positively influenced by diagnostic-remedial assistance. While it cannot be shown that either the amount or type of diagnostic remedial assistance had consistant effects across all science units, it is interesting to note that the groups receiving diagnostic assistance (i.e., either teacher-directed or student-directed remediation) scored higher on 10 of 12 cognitive measures and significantly higher on two unit measures.

It is not clearly understood why significant effects of diagnostic-remedial assistance were not consistent across all three science units. Such influences as a teacher effect, nature of content, or instructional activities may have acted independently or in combination to account for the results.

There were no difference detected among group means on the retention measure despite the real differences found on 2 of the 3 unit tests. There findings were not consistent with the retention studies cited by Block and Burns (1976).

One of the expected effects of diagnostic-remedial assistance is to minimize the differences in pupil achievement occuring as a result of differences in pupil aptitude. In this study the effects of aptitude on achievement were not discounted by diagnostic-remedial assistance. Without exception, the aptitude of pupils had a significant effect on achievement.

While significant differences in pupil attitudes toward science instruction were not found between groups, there is no indication that achievement gains attributed to diagnostic-remedial assistance occur at the expense of a decline in pupil attitudes toward instruction. It is conceivable that middle school pupils acclimated to group-paced instruction would be initially anxious or perhaps threatened by remediation and mastery expectations. If this was the case, a divergence in cognitive and affective progress may occur. No such divergence was detected as all groups expressed a positive attitude toward instruction.

The results of this study are in accord with much of the previous work on diagnostic-prescriptive procedures--diagnosis and prescription influences cognitive achievement but not consistently. However, the results of this study failed to support the findings of Goodson and Okey (1976). They found

consistent influences on achievement of both teacher- and student-guided remedial work with college age science students. Moreover, the influences held up on a retention test. Neither consistent influences of diagnostic-prescription on short term tests nor on retention measures were found in this study with middle school students.

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